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BANK DISTRESS OF LOW WATER WEIRS ON BIG CREEK, LA.(U)
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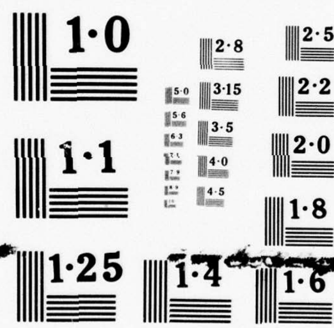
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BANK DISTRESS OF LOW WATER WEIRS ON BIG CREEK, LA.

by

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Several recently constructed low water weirs on Big Creek in northeastern Louisiana have shown signs of bank distress (slumping of slopes and severe erosion). The weirs were evaluated to determine possible causes of the distress, recommend remedial measures, and recommend direction for future studies. The evaluation included visual inspection, discussions with design and inspection personnel, soil sampling and testing, and soil and pore water chemistry determinations.

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20. ABSTRACT (Continued).

The distress problem was divided into two parts: ~~(a)~~ an erosion problem (gradual removal of material beneath and adjacent to the downstream edge of the slope protection) and ~~(b)~~ a bank distress problem (i.e., riprap and filter fabric displacement associated with apparent large soil displacements).

Erosion is a result of soil characteristics and the geometry of the downstream edge of the weir slope protection. Several causes of the bank distress were considered: (a) overbank, downslope erosion beneath the filter fabric, (b) stream current erosion of material from beneath the filter fabric and riprap, (c) unstable channel slopes (shear failure), (d) conditions during construction, and (e) flow slides. Flow slides were considered the most probable explanation for the bank distress, though more detailed information on construction conditions and slope stability analyses could change this conclusion. Recommendations are given for short-term remedial work, future weir design, and further studies to better define the causes of bank distress.

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Preface

The study reported herein was conducted by the Engineering Studies Branch (ESB), Soil Mechanics Division (SMD), Soils and Pavements Laboratory (S&PL), of the U. S. Army Engineer Waterways Experiment Station (WES) to study certain low water weirs of the U. S. Army Engineer District, Vicksburg (VD). The study was authorized by a letter from VD, dated 8 July 1977, Subject: Utilization of Plastic Filter Cloth on Low Water Weirs.

The investigation was conducted in May and June 1977 under the direction of Mr. J. P. Sale, Chief, S&PL, and direct supervision of Mr. C. L. McAnear, Chief, SMD by Messrs. G. B. Mitchell, Chief, ESB, and S. P. Miller. This report was prepared by Mr. Miller. Dr. E. B. Perry, SMD, arranged for soil chemistry laboratory data and interpretation. The assistance of Messrs. James Melton, Stacy McKnight, Arvis Dennis and David Stewart (all of the Vicksburg District) in providing information, advice and encouragement is gratefully acknowledged.

COL John L. Cannon, CE, and Mr. F. R. Brown were Director and Technical Director, respectively, of WES during the period of this study.

Contents

Conversion Factors, U. S. Customary to Metric (SI) Units of Measurement

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
inches	25.4	millimetres
feet	0.3048	metres

BANK DISTRESS OF LOW WATER WEIRS ON BIG CREEK, LA.

Introduction

1. The U. S. Army Engineer District, Vicksburg (VD), requested that the U. S. Army Engineer Waterways Experiment Station (WES) inspect and study problems associated with certain low water weirs located on Big Creek in northeastern Louisiana within the VD. This study was to evaluate possible causes of problems (primarily erosion and distress in protected slope areas of the weirs) which had developed during initial operation of the weirs and provide guidance for expedient repair of the distressed weirs. Several similar weirs are to be built in future VD projects. Thus, recommendations were to be made for (a) additional, more detailed, studies of the problems and (b) future design modifications to prevent or reduce the severity of the problems. Short-term recommendations were needed quickly to guide repair of distressed areas prior to the next high water season, therefore the study was brief and of a preliminary nature involving only information and laboratory data that could be quickly obtained. It was specifically requested that the design and performance of filter fabrics in the existing weirs be evaluated.

2. The study was initiated with a meeting between VD and WES personnel to define the problem and objectives. Field inspection of existing installations and soil sampling followed. Construction and design information, including reports of predesign studies and inspections of older weirs, was compiled. Preliminary laboratory tests were performed, discussions were held with field personnel, and possible causes of problems were evaluated. A second meeting was held in June 1977 between VD and WES personnel to review findings and recommendations.

3. Typical sections of the weirs are given in Figure 1. In general, a new channel which contained the weir was excavated within a bend of the existing creek. Sheet pile was installed and woven filter fabric and riprap protection placed continuously across the

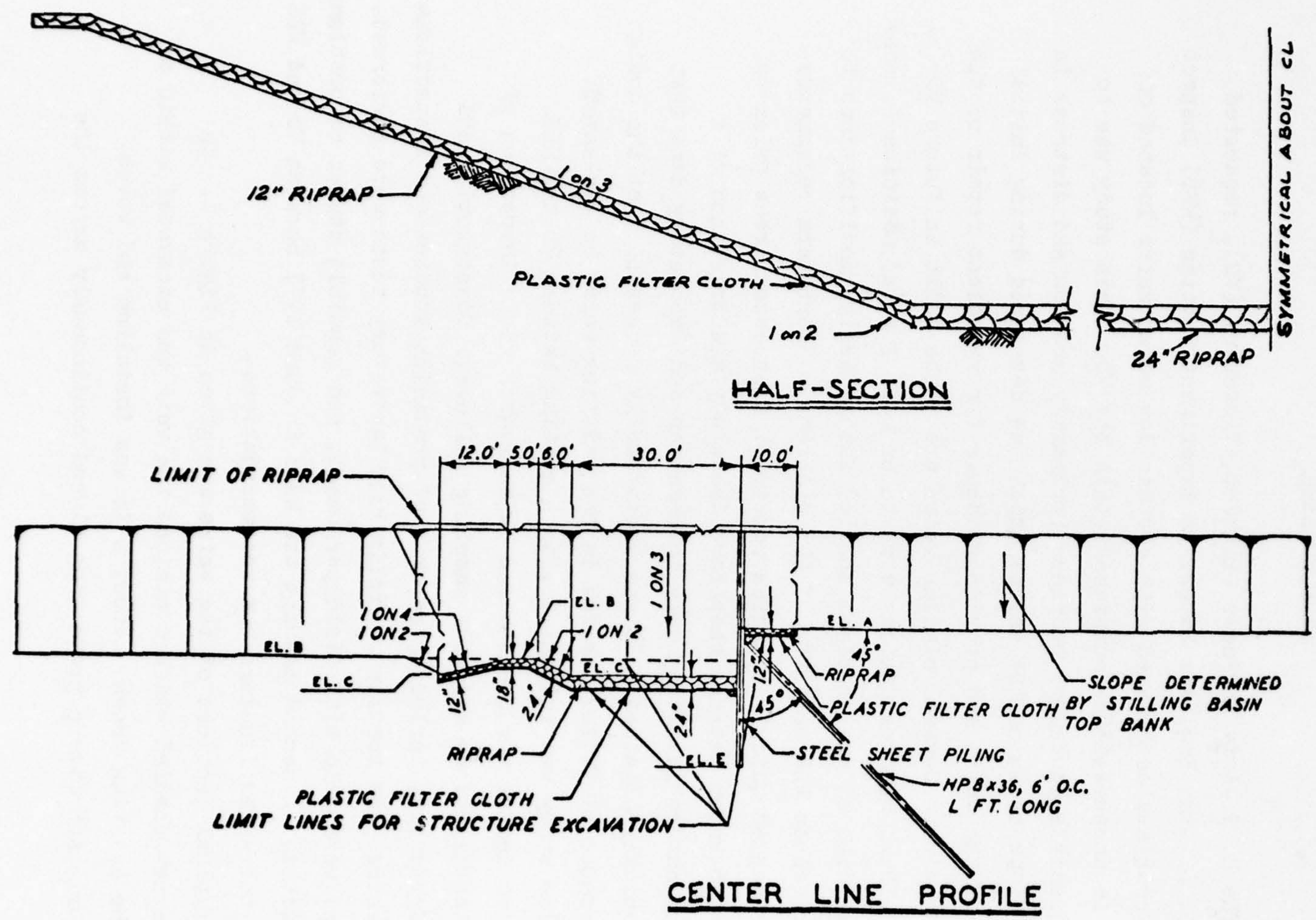


Figure 1. Typical weir cross sections

channel both upstream and downstream of the sheet pile. The riprap was placed directly on the fabric. It was evidently placed properly since no damage to the fabric was apparent during field inspection. The slope protection downstream of the sheet piling forms a stilling basin with an end sill. After the sheet pile and slope protection were installed, the excavation was connected with the creek and the old channel blocked to allow flow only through the weir.

Field Inspection

4. Field trips were made on 9, 10, and 18 May 1977 by personnel of the VD and WES. On 9 May, two weirs (Item 30A, Steele Bayou and Satartia weir) and a drainage structure (Little Sunflower Drainage Structure) were visited. The purpose of the trip was to observe installations similar to the Big Creek weirs. The weirs, Figures 2 and 3, were in good shape having only minor erosion in the adjoining unprotected bank areas. Both were in a clay soil, had been in operation for two or more years, and had the same general design as those on Big Creek. The drainage structure, Figure 4, had been built in a blocked channel and had not been put into operation. There has been no flow through the structure but water is ponded on each side in the associated blocked channels. The surrounding levee has been overtopped during floods. Slope protection on one side of the structure consisted of two different types of protection, side by side, extending from top of bank on one side across the channel bottom and to the top of bank on the opposite side. The protection nearest the structure was a granular filter on the natural soil overlain by riprap. The adjoining protection was a woven filter fabric overlain by an articulated concrete mattress. The concrete blocks of the latter section had experienced surface displacement and channels and voids were apparent beneath the concrete blocks and fabric. The area of granular filter and riprap protection exhibited no signs of distress. The soil inspected beneath and near the distressed section appeared to be a silty sand or sandy silt.

5. On 10 May, several personnel from the VD and WES visited the weirs on Big Creek in Louisiana which are the subject of this study. The creek was

Figure 2. Item 30A weir

Figure 3. Satartia weir

Figure 4. Little Sunflower Drainage Structure

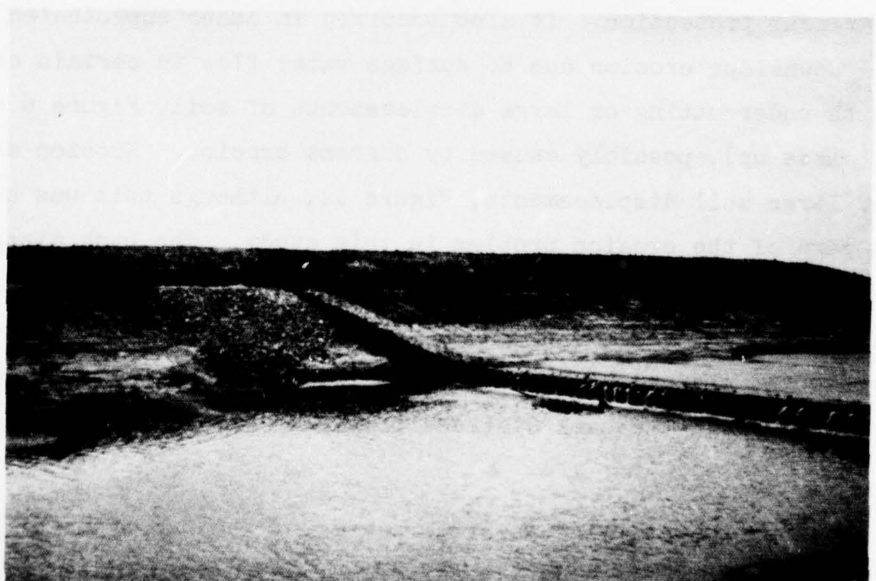


Figure 5. Reach 1 - Weir 1

divided into two reaches, Reach 1 containing two weirs, (Reach 1 - Weir 1 and Reach 1 - Weir 2), and Reach 2 containing four weirs numbered in the same manner. Figures 5 through 9 are general views of the weirs taken in May 1977. Weir 2 of Reach 2 is not shown, but was in a generally good condition similar to Weir 1, Reach 2. The general condition of each weir is described in Table 1. The weirs were visited again on 18 May and soil samples were taken from locations listed in Table 2.

Investigation of Causes

Problem definition

6. In order to study possible causes of the distress and then consider remedies in an organized manner, the distress problem was defined in two parts: (a) an erosion problem (i.e., gradual removal of material beneath and adjacent to the downstream edge of the slope protection) and (b) a bank distress problem (i.e., riprap and filter fabric displacement associated with apparent large soil displacements). Erosion, (a), was assumed to have been caused by downslope flow of surface water and current action. The problem was generally confined to unprotected channel banks at the downstream end of the riprap protection. It also occurred in other unprotected areas, Figure 10. Downslope erosion due to surface water flow in certain cases was combined with undercutting or large displacements of soil, Figure 6 and Figure 11 (close up), possibly caused by current erosion. Erosion also took place after large soil displacements, Figure 12, although this was not considered as part of the erosion problem in this study. The bank distress problem, (b), when present in the protected area, appeared only in the downstream riprapped area, Figures 6 and 8. Large slope displacements were evident in the unprotected channel banks near the weir, Figure 9. These were not directly considered in the bank distress problem.

Testing and reviews

7. In order to determine possible causes of the two types of problems, limited laboratory testing was performed and existing data were reviewed. Grain-size distribution, Atterburg limits, soil chemistry, and

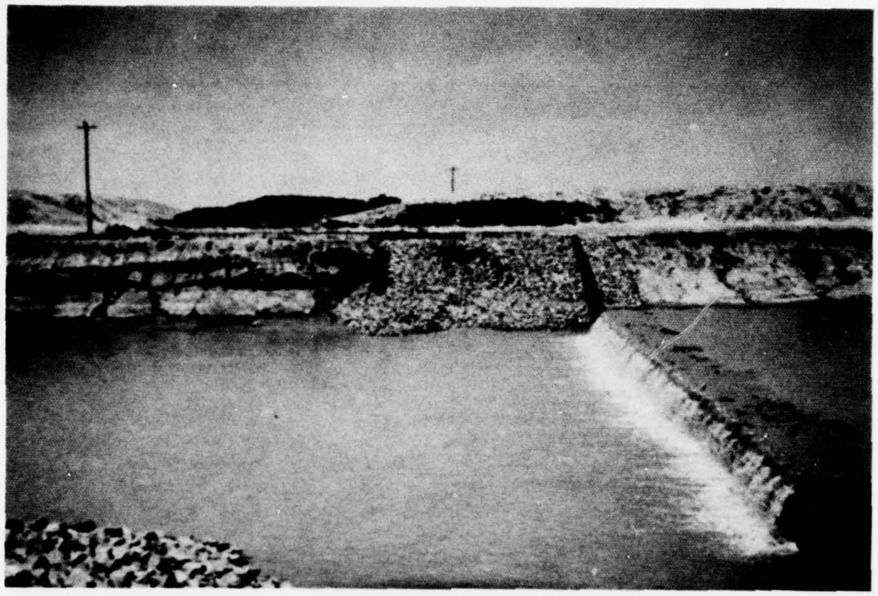


Figure 6. Reach 1 - Weir 2

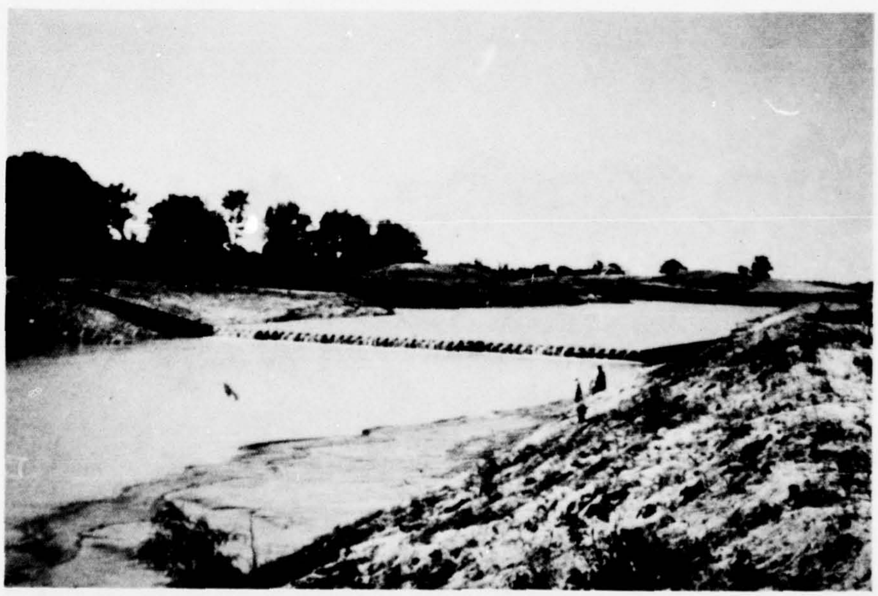


Figure 7. Reach 2 - Weir 1

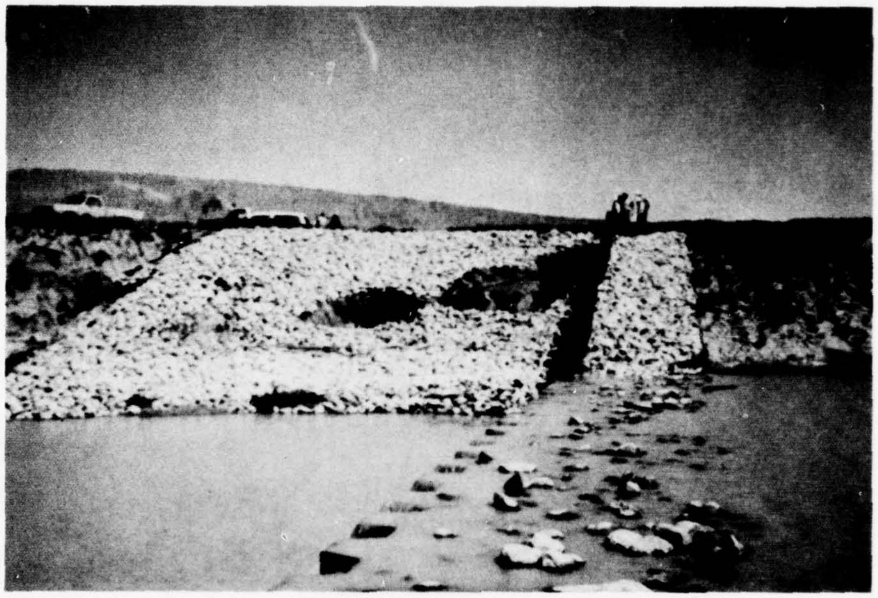


Figure 8. Reach 2 - Weir 3, Left or North bank

Figure 9. Reach 2 - Weir 4 upstream area

Figure 10. Erosion in unprotected bank
Reach 2 - Weir 3

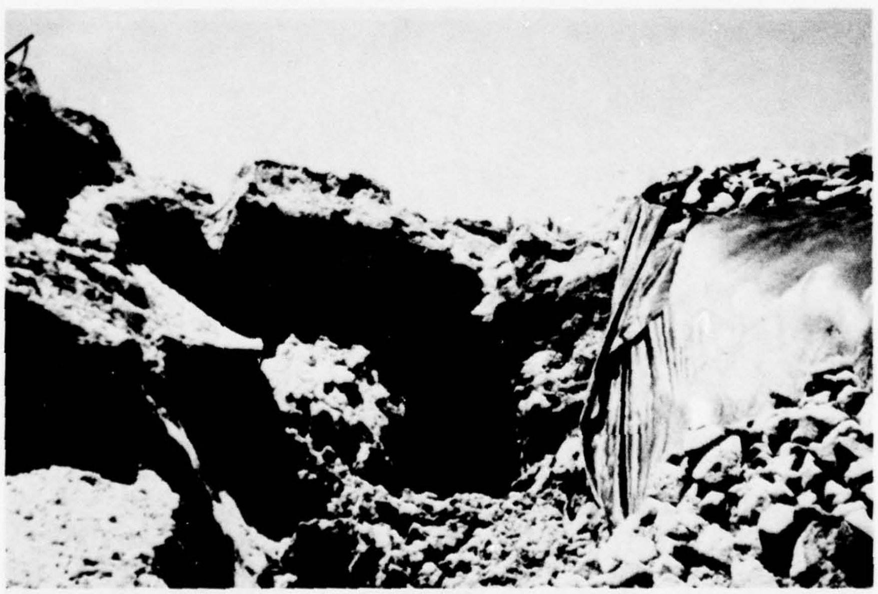


Figure 11. Edge of downstream riprap showing soil
and riprap loss Reach 1 - Weir 2

Figure 12. Erosion evident when filter fabric removed Reach 2 - Weir 3

Figure 13. View of "vee" at downstream edge of riprap. End sill is visible just at water surface across channel

soil pore water chemistry were determined for each weir site on Big Creek, Plates 1 through 6 and Appendix A. The grain size was used for soil classification and to review filter fabric criteria for piping. Soil and soil pore water chemistry test results were used for predicting erodibility.

8. Existing data and studies directly and indirectly relating to the weirs were reviewed. These data and studies included exploratory soil borings,[1] previous field inspections of similar weirs,[2] a WES Hydraulics Laboratory weir model study,[3] determination of weir operating age, studies describing characteristics of areas subject to flow slides,[4,5] and studies of filter fabric uses.[6,7]

Possible causes of distress

9. Table 3 is a summation of qualitative and quantitative data for each of the Big Creek weirs and the two weirs in Mississippi visited on field trips. The Mississippi weirs were generally in good shape. From visual inspection they appeared to be located in clayey soils. No soil sampling, testing, or reviews were done for these weirs. Most of the six Louisiana weirs had experienced erosion and, in two cases bank distress problems during their first season of high-water operation. The exception was Reach 1 - Weir 1. Again, this weir was located in a primarily clay soil as shown in Table 3, Plate 1, and the soil boring profiles.[1]

10. The erodibility of the soils was obvious from visual inspection at almost all the weirs. Soils common to this area include relatively fine silts and silty sands with little or no cohesion. The downstream edge of the slope protection is an area of concentrated erosion. The downstream end sill is carried across the bottom and up each side of the channel. The riprap and filter cloth slope protection terminate at the downstream toe of the end sill. This produces a "vee" or "trough" up the channel bank, one side having slope protection and the other side none, Figure 13. In the more erodible soils, this configuration would tend to accelerate erosion if surface runoff has access to the vee. These soils would also be more susceptible to undercutting and current erosion in the unprotected bank just downstream of the fabric and riprap. This logically would progress back to and under the fabric and riprap. This has apparently happened at several of the weirs. The erosion has removed soil from beneath the downstream

edge of the filter fabric, causing displacement of the fabric and subsequent displacement and loss of riprap, Figure 11.

11. Laboratory soil chemistry tests were performed on soil pore water samples from each of the Big Creek weirs to determine if the soils tended to be dispersive, Appendix A. Dispersive soils are defined as highly erodible fine-grained soils.[8] Results are plotted on the graph, Figure 14 taken from reference 8. Most of the samples were located in Zone C (neither definitely dispersive or nondispersive). Samples from Reach 2 - Weir 2 and Reach 2 - Weir 3 are not plotted since they are nonplastic and therefore should not contain sufficient colloids to support dispersive erosion. However, such soils are known to have low resistance to erosion.[9] Figure 15 shows some of the major erosion with resulting loss of riprap along the downstream edge of Reach 2 - Weir 3. The sample from Reach 1 - Weir 1 (which had only experienced minimal erosion), plotted in Zone B (nondispersive). Further definition of the dispersiveness of soils is possible by performing a pinhole test.[9] This test was not performed during this preliminary study.

12. Bank distress (riprap, fabric, and soil displacement) is evident in Figures 6, 8, and 16. Downslope bulges were visible in two cases: one, a bulge in the filter fabric near the water line on the right bank of Reach 2 - Weir 3, could be made to pump out muddy water by stepping on it, Figure 17; the second is shown in the outward displacement of riprap at the water line immediately downstream of the sheet pile on the right bank of Reach 1 - Weir 2, Figure 6. Possible explanations of the bank distress include:

- a. Overbank, downslope erosion beneath the filter fabric.
- b. Stream current erosion of bank material from beneath the filter fabric and riprap with subsequent slumping of overlying soil.
- c. Unstable channel slopes (shear failures) because of low soil strengths coupled with sudden drawdown.
- d. Condition(s) during construction.
- e. Flow slides.

Possibilities c and d were not considered further because of lack of available strength data or slope stability design analysis, lack of observations to relate channel stages to bank distress, and lack of

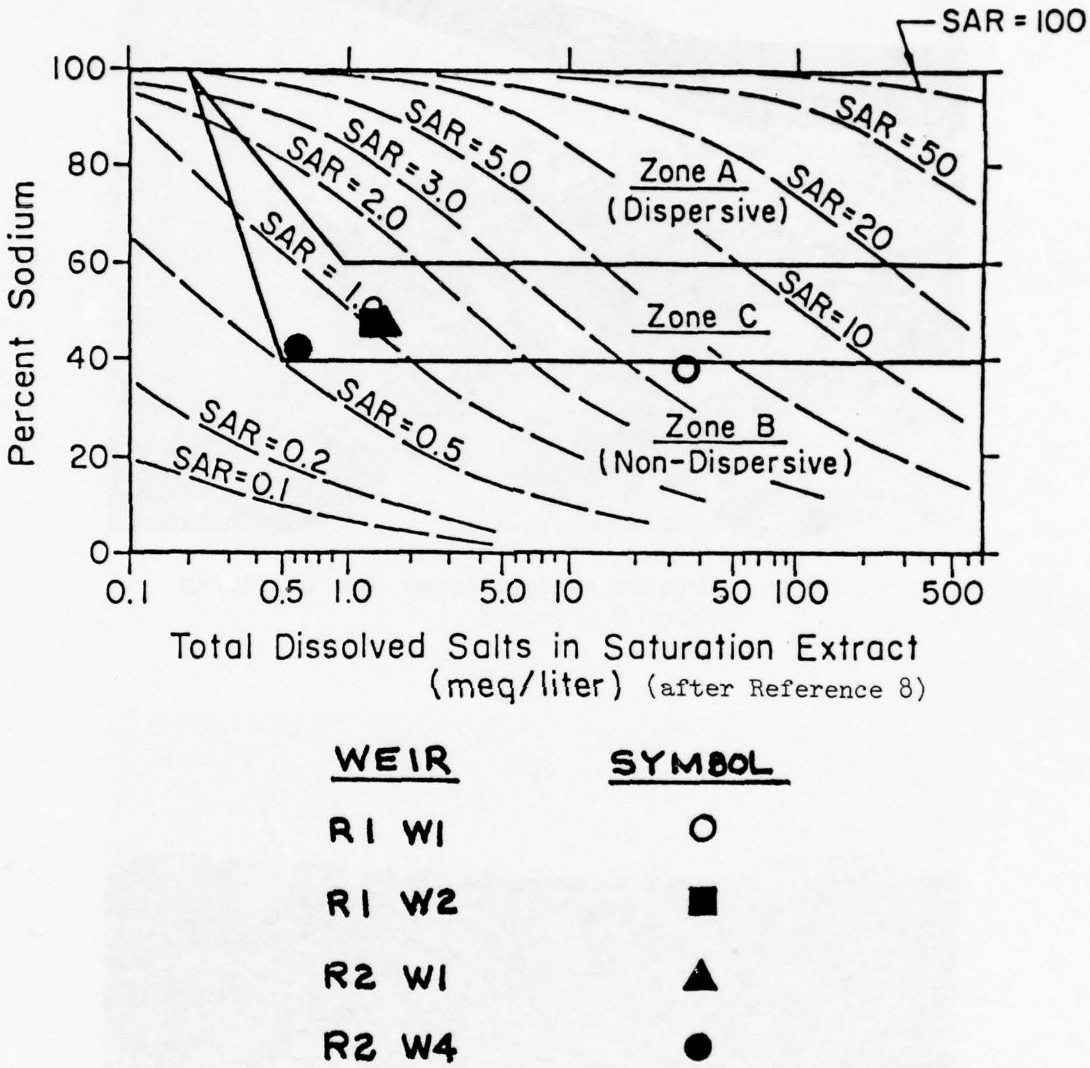


Figure 14. Relationship between dispersion and soil pore water chemistry based on pinhole erosion tests and experience with erosion in nature (Reference 8)

Figure 15. Erosion at downstream edge of riprap
Reach 2 - Weir 3

Figure 16. Bank distress at Reach 1 - Weir 2

Figure 17. Bulging of filter fabric Reach 2 - Weir 3

Figure 18. Erosion beneath cloth possibly prior to soil displacement Reach 1 - Weir 2

knowledge of construction conditions. Personnel observing construction indicated that stability problems due to seepage existed during construction, but the relationship of these problems to the bank distress was not known. The slopes were 1 vertical on 3 horizontal which for most soil conditions is a conservative design. The idea of soil loss beneath the fabric due to downslope erosion, a, was considered improbable by most observers after inspecting the soil conditions beneath the filter fabric. Though there was evidence of erosion beneath the filter fabric, Figure 12, this apparently happened after the soil displacements. The erosion beneath the fabric appeared to have developed after the relatively large soil displacements caused voids bridged by the fabric. At Reach 1 - Weir 2, Figure 18, some water had apparently entered beneath the fabric and riprap at the top of the bank and exited at the area of bank displacement. This erosion channel was relatively small and could have developed either before or after bank displacement.

13. If bank material had passed from beneath the fabric and riprap and been carried downstream by the current, b, it would have had to pass either through the fabric openings, fabric overlaps, or torn openings in the fabric. Inspection of the sites did not indicate that the latter two mechanisms were responsible for the soil loss. Thus soil passage through the cloth openings was considered. This mechanism is known as piping and criteria from the Corp of Engineers guide specification for filter cloth[10] was used to evaluate the piping potential of soils from each of the weirs. The fabric used was "Laurel Erosion Control Cloth," with an equivalent opening size (EOS) of sieve No. 100 and a percent open area of 4.3 percent as given in the specification.[10] This fabric meets the criteria for piping.

14. The last mechanism considered was displacement by flow slides. Flow slides along the Mississippi River have been studied for a number of years and criteria for prediction have been developed.[5] Essentially the soil conditions found to be associated with a flow slide are:

a. The presence of three basic soil types: a cohesive top stratum, underlying fine sand, and, in turn underlying coarse sands.

b. Flow failures have never been known to extend into the lower coarse sands.

c. The stability of a given slope is dependent upon the relative thickness of (1) the overburden, and (2) a zone of fine sand in the upper sands (called zone A).

Zone A sands have been at least 20 ft* thick at Mississippi River flow slide locations and the ratio of overburden thickness to zone A sand thickness, called the R value, has been 0.85 or less. The overburden and two underlying sands and overburden are identified by grain size. This information was not available from the boring profiles.[1] The boring profiles[1] were used to establish relative locations and thicknesses of fine-grained soils (CH, CL, ML) and coarse-grained soils (SP-SM, SP). Generally the boring located at the weir site was used and the boring 150 ft downstream of the weir location provided verification that soil conditions given by the weir boring generally existed in the downstream area of the weir structure. Table 4 is a subjective evaluation of flow slide potential for each weir site. The specific criteria from the Mississippi River Studies[5] was not applied, rather the existence of approximately equal thicknesses of fine-grained soil strata underlain by a coarse-grained soil strata located between downstream channel bottom and top of bank was considered to indicate a susceptibility to flow slides. Comparing Table 4 with Table 3 shows that of the four weir locations with potential for flow slides, two--Reach 1 - Weir 2 and Reach 2 - Weir 3 have had major bank distress. The failure surface for these distressed areas tends to be neck-shaped with a narrow throat at the outlet (or downbank portion) of the failure. This has been identified as a characteristic of flow failures.[5] In general, all of the flow failure criteria and characteristics defined by the Mississippi River Studies[5] are not met. Enough of the criteria and general characteristics of this type of failure are evident from this brief study to make this a plausible explanation for the bank distress.

15. A factor also considered in this explanation is the use of filter fabric. In Reach 1, the fabric was placed parallel to channel flow with the lower fabric overlapping the upper fabric, while in Range 2 it was placed perpendicular to channel flow with the upstream fabric overlapping the down-

* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 4.

stream fabric. Visual observation did not indicate a loss of soil through the overlaps at any of the weirs. The possibility that the fabric would not allow the relief of hydrostatic pressures in the bank during sudden drawdown conditions exits. The percent of open area listed for the fabric in the CE Guide Specification for plastic filter cloth[10] was 4.3 percent. Relative to other fabrics in the partial list of that specification, this is a low percent open area. If the hydrostatic pressure was not quickly relieved through the fabric when the water level in the channel dropped after high stages, the possibility of flow slides would increase. Somewhat similar situations have previously been reported. Reference 6 describes a test section along the Mississippi River where filter fabric was placed beneath the riprap upbank from some articulated concrete mattress. Bulges of the fabric at the intersection of the riprap and mattress were thought to have been caused by downslope movement of fine sand when excessive hydrostatic pressures developed beneath the cloth during falling river stages. Sampling of the fabric indicated a layer of fines beneath the fabric and it was stated that the cloth openings were evidently clogged. The percent open area for this cloth was around 5 percent. The writers also felt that the phenomenon was affected by the use of riprap upbank from the mattress because the mattress reduced the effective area for water to pass from beneath the fabric downbank of the riprap. A survey of field installations conducted as part of a previous WES filter fabric study[7] recorded another incident where seepage within the slope (composed of a fine sand with some silt and shell fragments) was not able to pass through a fabric (percent open area 5.2 percent) fast enough to prevent hydrostatic pressure from developing beneath the fabric. The fabric was apparently lifted or floated out of position. It was stated "...in instances where the revetment is relatively light and where relatively high seepage velocities or rapid fluctuations in the differential hydrostatic pressures can occur, opening areas exceeding 4 percent may be required." The condition of the slope after fabric failure was not mentioned. A fabric in the same area with a more open weave did not fail. Grain sizes of soil samples taken for this study indicated that the EOS might be increased to a No. 70 sieve according to filter

fabric criteria.[10] This would only increase the percent open area by about 1 percent according to the list of cloths in the Guide Specification.[10]

Discussion and Conclusions

Study limitations

16. As the study was limited and preliminary in nature, only tentative conclusions are possible. In particular, information in the following areas was limited or unavailable:

- a. Relationship of rise and fall of channel stages and ground-water levels in channel banks to bank distress development.
- b. Problems with slope stability due to seepage and erosion during construction.
- c. Soil strength data for slope stability analysis.
- d. Effect of filter fabric on hydrostatic pressure relief during falling channel stages i.e. permeability of fabric with respect to soil.

Erosion problem

17. The high erodibility of the soils in which several of the weirs are located is evident from inspection. There is no definite indication that any of these soils are dispersive, though further testing using the pinhole test apparatus[9] should provide more definite results.

Bank distress problem

18. Five possible explanations for bank distress in the downstream riprapped areas were given in paragraph 12. These are listed below with the conclusion reached or why no conclusion was reached.

- a. Overbank downslope erosion beneath the filter fabric. This was not considered a possible cause since it was not substantiated by visual observation of the channel bank areas beneath the filter fabric.
- b. Stream current erosion of bank material from beneath the filter fabric and riprap. The filter fabric opening size met the CE guide specification criteria[10] for piping when compared with the grain size of soil samples taken from beneath the fabric. Therefore, this was not considered a likely explanation for the bank distress.
- c. Unstable channel slopes (shear failures) because of low soil strengths or sudden draw down. No analysis of slope stability was made because of data and time limitations. Though the

slopes are 1 vertical on 3 horizontal, which is normally considered conservative, no conclusion was made for this bank distress explanation.

d. Condition(s) during construction. Limited information on construction procedures and problems prevented a conclusion.

e. Flow slides. The general soil conditions for the development of flow slides exist at some of the weir sites. The configuration of the soil displacements at the distressed sites resembles that of a flow slide. Linking these factors to the possibility that hydrostatic pressures in the channel bank were slow in dissipating due to low open area (insufficient permeability) of the filter fabric makes this explanation plausible.

In summary, from the facts known and explanations considered, flow slides are considered a most probable explanation for the bank distress. It must be noted that further information about explanations c and d could easily change this conclusion. VD personnel are gathering more information that will provide more insight to slope stability and construction conditions.

Recommendations

Short term

19. To alleviate the erosion problem, it is recommended that:

a. The "vee" shaped area extending up the bank at the downstream edge of the riprap should have protection (filter fabric and riprap) on both sides. This could be accomplished by extending slope protection another 5 to 10 ft downstream.

b. Surface water should be routed away from the channel banks in the area of the weir and its slope protection including a short distance upstream and downstream of slope protection. This could be accomplished by a slight slope away from the channel and/or a small protective berm just back of the top of bank.

c. Convential erosion protection measures (soil stabilization with vegetation, lime, soil cement, etc.) could be used just upstream and downstream of the weir on the unprotected slopes.

As long as the weirs are located in erodible soils, current attack on the downstream end of the slope protection will be a continuing problem. In these soils unprotected banks will be eroded by the current and this will eventually work back to the slope protection. Continuing maintenance will be necessary.

20. The conclusion that flow slides are a possible cause of bank distress precludes definite recommendations. Previous studies[4,5] have only hypothesized what should be done to decrease susceptibility to flow slides. Primarily increasing density of the underlying sands and good drainage are the most important considerations. Practical, inexpensive methods of increasing in situ density of the sands are not available. Though not proved for this study, the possibility exists that the filter fabric hindered rapid dissipation of hydrostatic pressures within the channel bank. Further study of this possibility is warranted. Use of a granular filter in place of filter fabric with a low percent open area would give better assurance of quick drainage of sands in the channel bank. Other preventive measures suggested include flattening of slopes and increasing lateral pressure on the sand by adding surcharge to the slopes.[4] Apparently no studies have been performed to determine to what extent these measures should be taken or of their effectiveness. Further information should be gathered concerning construction conditions and slope stability analysis made of some worst cases to provide a basis for consideration of these two possible causes of bank distress.

Future designs

21. Recommendations for future weirs include the short-term recommendations concerning erosion listed above. Additionally, weir sites should be located in clayey soils (as are Reach 1 - Weir 1, and the two Mississippi weirs visited on the field trips) to reduce the possibility of flow-type bank failures and to reduce erosion problems. It is understoood that other considerations such as real estate, channel elevation, etc. are involved in site selection. If a weir is constructed in sandy silty soils, then a filter fabric having a large percent open area while still meeting piping criteria or a granular filter should be used beneath the riprap.

Further studies

22. Further studies should be made to aid identification of specific reasons for bank distress in the weirs. Once these reasons are known, preventive design measures could be developed for future weirs. The most directly applicable studies would be a continuing monitoring program for existing weirs to observe and record weir performance. This should include periodic observation and recording of weir condition with written

reports and photographs. Channel stages experienced at the weirs and hydrostatic pressures in the channel banks should be recorded and coordinated with the appearance of distress. These reports should be used to make periodic comparisons of performance of weirs in different soils and subjected to different conditions. A test section could be installed in the downstream riprapped area of a weir to compare the performance of a filter fabric and a granular filter beneath the riprap. Laboratory testing of soils from weir sites and filter fabrics in a permeameter could be conducted to determine the effect of the fabric on dissipation of hydrostatic pressure in the soils. These laboratory tests should include comparisons of the effectiveness of filter fabrics and granular filters. This should include comparison of head losses across the filter fabric and granular filter and changes in head losses with time. Laboratory results would be related to field performance to develop design criteria for prevention of slow hydrostatic pressure release in the protected channel banks. As stated previously, further information should be gathered concerning construction conditions, and slope stability analyses of the worst cases should be performed. Cost effectiveness of possible solutions would be needed before making a choice.

References

1. a. U. S. Army Engineer District, Vicksburg, "Big and Colewa Creeks-Reach 1B Station 0+00 to Station 1004+00 Channel Enlargement Boring Profiles" Drawing 15, File No. OB-15-89, November 1972.

   b. U. S. Army Engineer District, Vicksburg, "Big and Colewa Creeks-Reach 2 Weir Station 1033+50, 1226+00, 1657+50, and 1955+35 Boring Profiles" Drawing 14, File No. OB-15-90, April 1975.

2. U. S. Army Engineer District, Vicksburg, "Boeuf River, Miles 32.6 to 45.8 and Big and Colewa Creeks," General Design Memorandum No. 1, Supplement A, Appendix C, September 1966.

3. Ables, J. H., Jr. and Boyd, M. B., "Low-Water Weirs on Boeuf and Tensas Rivers, Bayou Macon, and Big and Colewa Creeks, Arkansas and Louisiana," Technical Report H-69-13, October 1969, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, MS.

4. Banks, D. C. and Strohm, W. E., Jr., "Methods of Preventing Flow Slides," Potamology Investigations Report 12-16, October 1965, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, MS.

5. Torrey, V. H., III and Gann A. R., "Verification of Empirical Method for Determining Riverbank Stability, 1970 and 1971 Data" Potamology Investigations Report 12-22, April 1976, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, MS.

6. Fairley, J. G. et al., "Use of Plastic Filter Cloth in Revetment Construction," Potamology Investigations Report 21-4, June 1970, U. S. Army Engineer District, Memphis, CE, Memphis, TN.

7. Calhoun, C. C., Jr., "Development of Design Criteria and Acceptance Specifications for Plastic Filter Cloths," Technical Report S 72-7, June 1972, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, MS.

8. Sherard, J. L., Dunnigan, L. P., and Decker R. S., "Identification and Nature of Dispersive Soils," Journal of the Geotechnical Engineering Division, American Society of Civil Engineers, Volume 102, No GT4, April 1976, pp 287-301.

9. Department of the Army, CE, Laboratory Soils Testing, Office of the Chief of Engineers, Engineer Manual EM 1110-2-1906 (Draft Appendix for pinhole erosion test), Washington, D. C., 1977.

10. Department of the Army, CE, Plastic Filter Cloth, Office of the Chief of Engineers, Guide Specification CW 02215, Washington, D. C., October 1975.

Table 1

General Condition of Big Creek Weirs

Weir	General Condition
Reach 1 Weir 1	Good shape, minor erosion upstream and downstream of weir slope protection.
Reach 1 Weir 2	Bank distress in downstream riprap on both sides of channel, severe erosion at downstream edge of riprap on right side undercutting fabric with loss of riprap - On left side at bank distress location about ½ way down bank seepage noted beneath filter fabric - there had been no rain in area for over 1½ weeks - soil sandier at this point than at top of bank.
Reach 2 Weir 1	Good shape except for some erosion at downstream edge of riprap.
Reach 2 Weir 2	Good shape except for erosion affecting downstream edge of riprap.
Reach 2 Weir 3	Bank distress in downstream riprap on north or right side of channel - erosion just downstream of sheet pile on same side, evidently occurred after soil displacement as did erosion beneath fabric - bulging fabric just above water level, when stepped on muddy water come through - large erosion gully just upstream of upstream riprap on left side also erosion downstream same side - on right side erosion just downstream of riprap - had undercut fabric and caused loss of riprap.
Reach 2 Weir 4	Good shape except erosion at downstream edge of riprap affecting riprap - erosion and bank distress in unprotected areas adjacent to riprap.

Table 2

Location of Soil Sampling of Big Creek Weirs

Weir	Location of Soil Samples
Reach 1 Weir 1	One-half way from top of bank to water (low) ≈ 12' downstream of downstream edge of riprap on left or east side.
Reach 1 Weir 2	One-half way from top of bank to water (low) ≈ 20' downstream of sheet pile in "slumped" area of riprap on east or left side.
Reach 2 Weir 1	One-half way from top of bank to water (low) ≈ 10' downstream of downstream edge of riprap on east or left side.
Reach 2 Weir 2	One-half way from top of bank to water (low) ≈ 17' downstream of downstream edge of riprap on north or right side.
Reach 2 Weir 3	One-half way from top of bank to water (low) ≈ 12' downstream of sheet pile in "slumped" area on north or right side.
Reach 2 Weir 4	One-half way from top of bank to water (low) ≈ 25' upstream from sheet pile on west or right side.

Table 3

Weir Characteristics

Weir	Age*	Erosion	Bank Distress	Soil Class.	PI	Dispersion Characteristics**
R1 W1	6 mon.	Minimal	None	CL	12	Nondispersive
R1 W2	8 mon.	Major	Major	CL	9	Possibly dispersive
R2 W1	4 mon.	Mild	None	CL	16	Possibly dispersive
R2 W2	4 mon.	Mild	None	SM	Nonplastic	Nondispersive***
R2 W3	7 mon.	Major	Major	SP-SM	Nonplastic	Nondispersive***
R2 W4	6 mon.	Major	None	CL	21	Possibly dispersive
Satartia	2 yr.	Minimal	None	Clay	--	--
Item 30A	--	Minimal	None	Clay	--	--

* Approximate operating age as of May 1977 as determined from construction logs

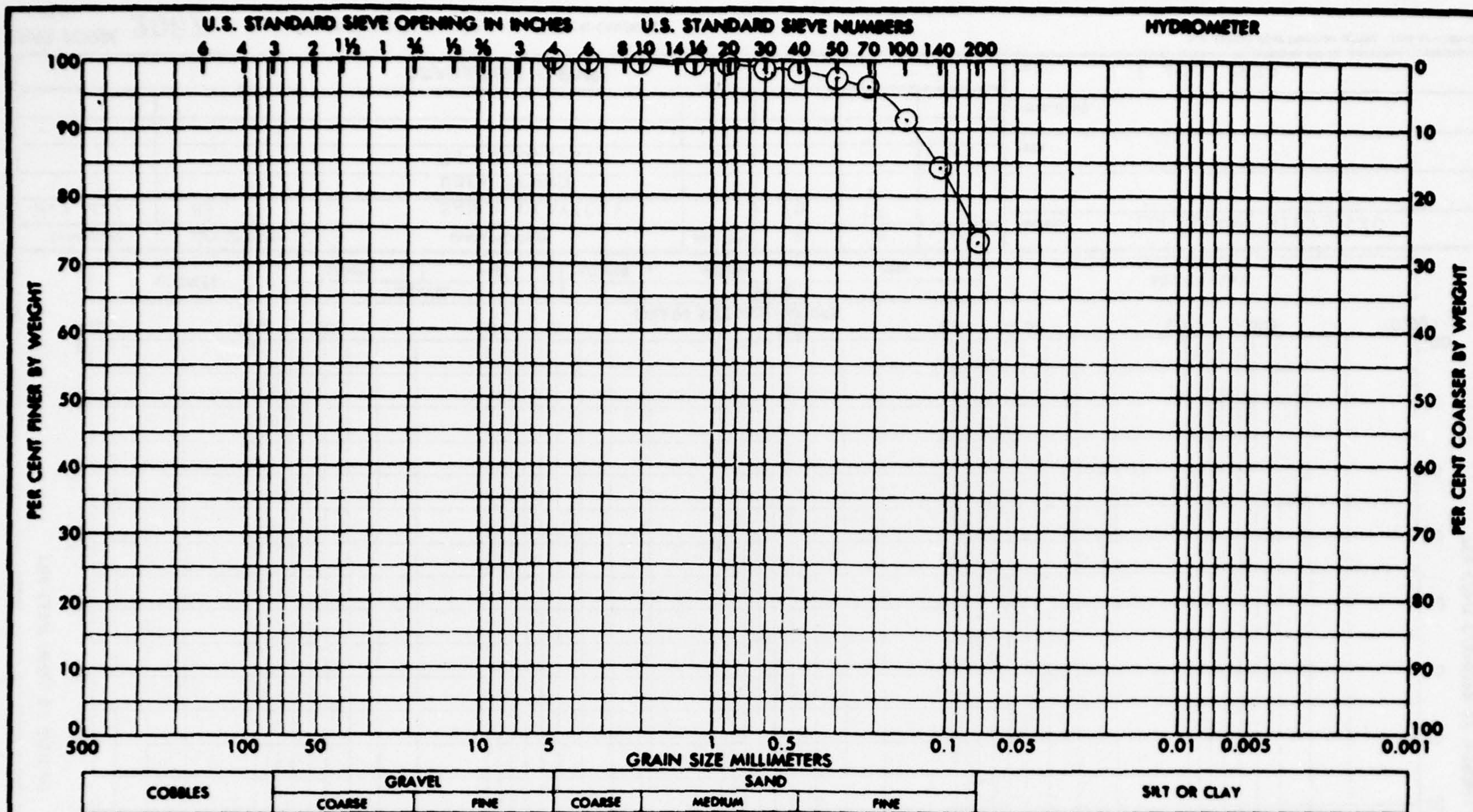
** See Figure 14

*** Soils with the fraction finer than 0.005 mm ≤ 12 percent and with a plasticity index ≤ 4 generally do not contain sufficient colloids to support dispersive erosion. However, such soils are known to have low resistance to erosion and the dispersion characteristics would add little to the known field performance of the soils (Reference 9)

Table 4

Weir Flow Slide Potential

Weir	Potential		
	Possible	Limited Possibility	Not Susceptible
Reach 1 Weir 1			X
Reach 1 Weir 2	X		
Reach 2 Weir 1		X	
Reach 2 Weir 2	X		
Reach 2 Weir 3	X		
Reach 2 Weir 4	X		



SAMPLE NO.	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
R-1 W-1	Bag	SANDY CLAY(CL)		29	17	12
		Dark Brown				
		Gs= 2.67(est)				

GRADATION CURVES

PROJECT LOUISIANA WIERS VXD

AREA

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DATE 1 JUNE 1977

ENG FORM 2087
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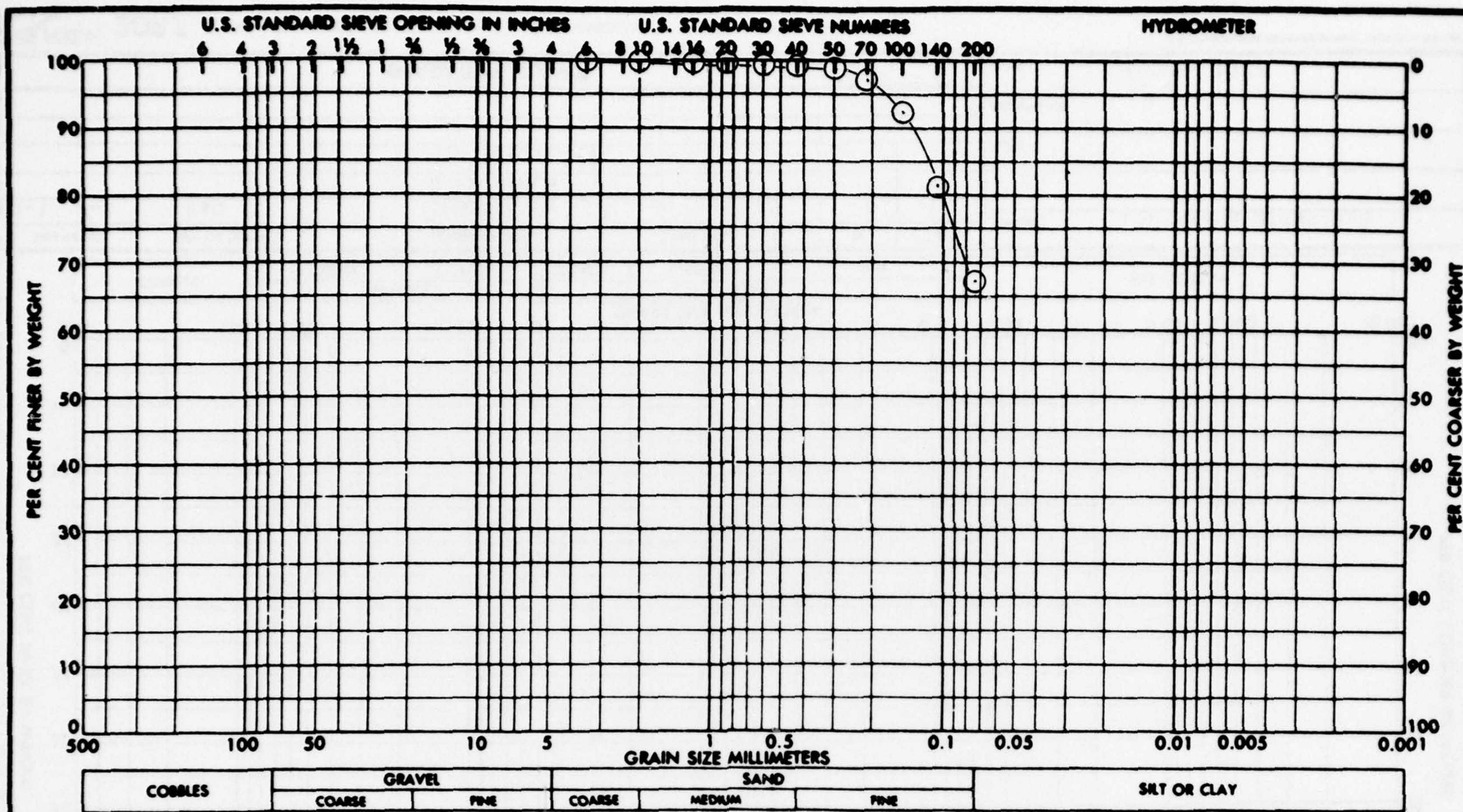

SAMPLE NO.	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
R-1 W-2	Bag	SANDY CLAY(CL)		26	17	9
		Dark Brown				
		Gs= 2.67(est)				

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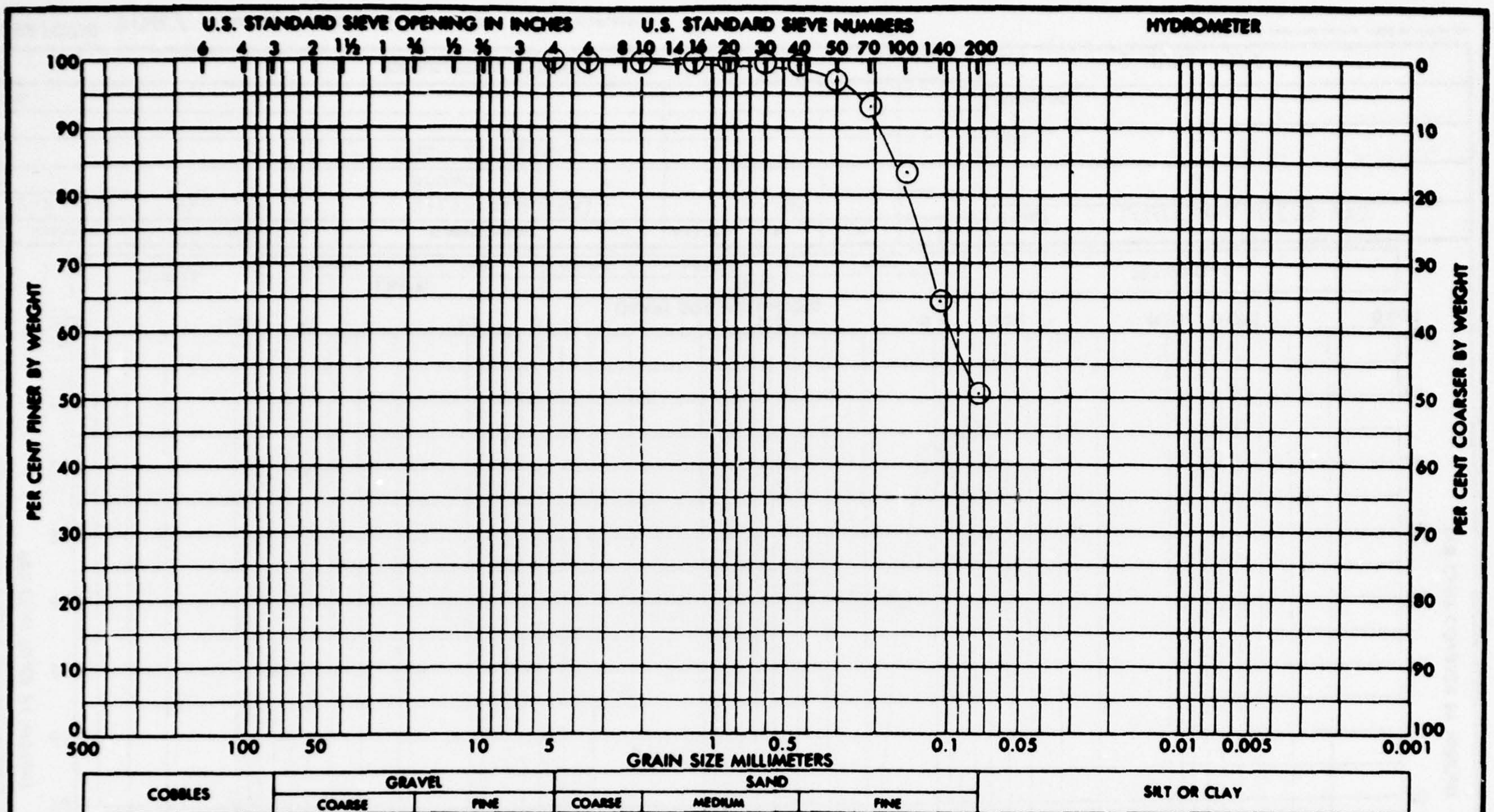

SAMPLE NO.	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
R-2 W-1	Bag	SANDY CLAY(CL)		30	14	16
		Light Brown				
		Gs= 2.66(est)				

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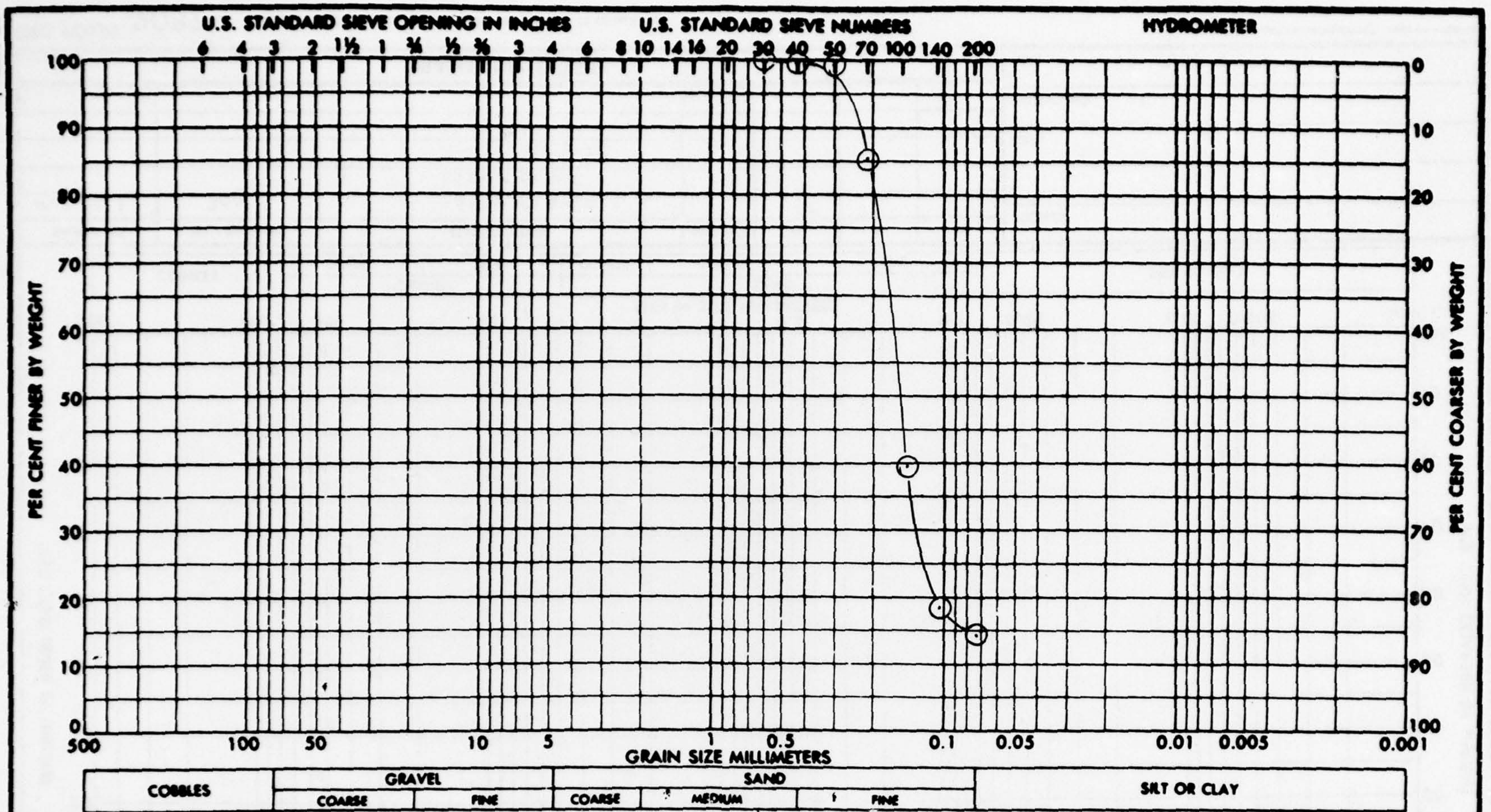

SAMPLE NO.	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
R-2 W-2	Bag	SILTY SAND (SM) Brown Gs= 2.66(est)		NP		

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DATE	1 JUNE 1977

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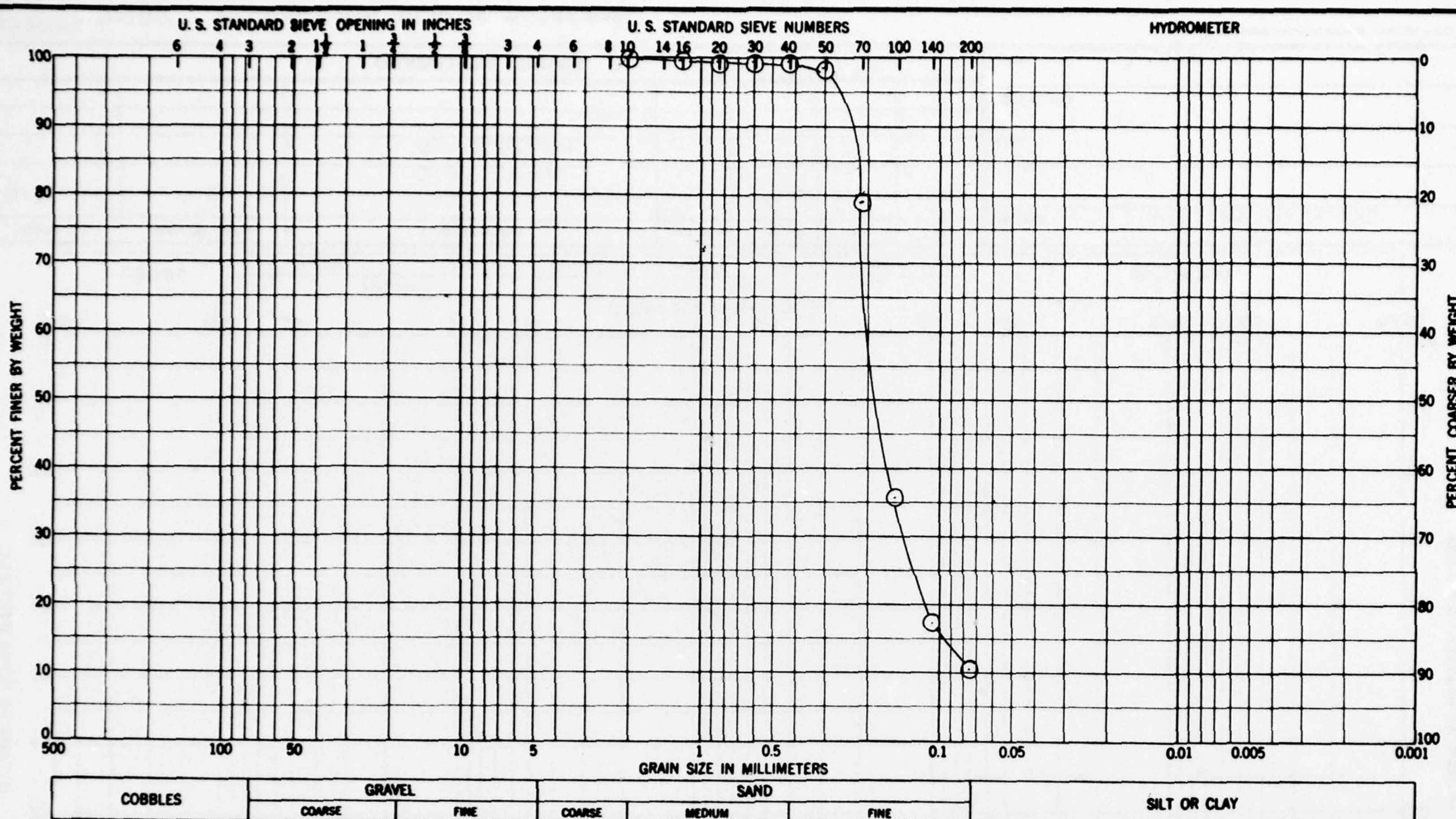

Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
R-2 W-3	Bag	SAND(SP-SM)		NP		
		Brown				
		Gs= 2.65(est)				

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Area

Boring No.

Date 1 JUNE 1977

GRADATION CURVES

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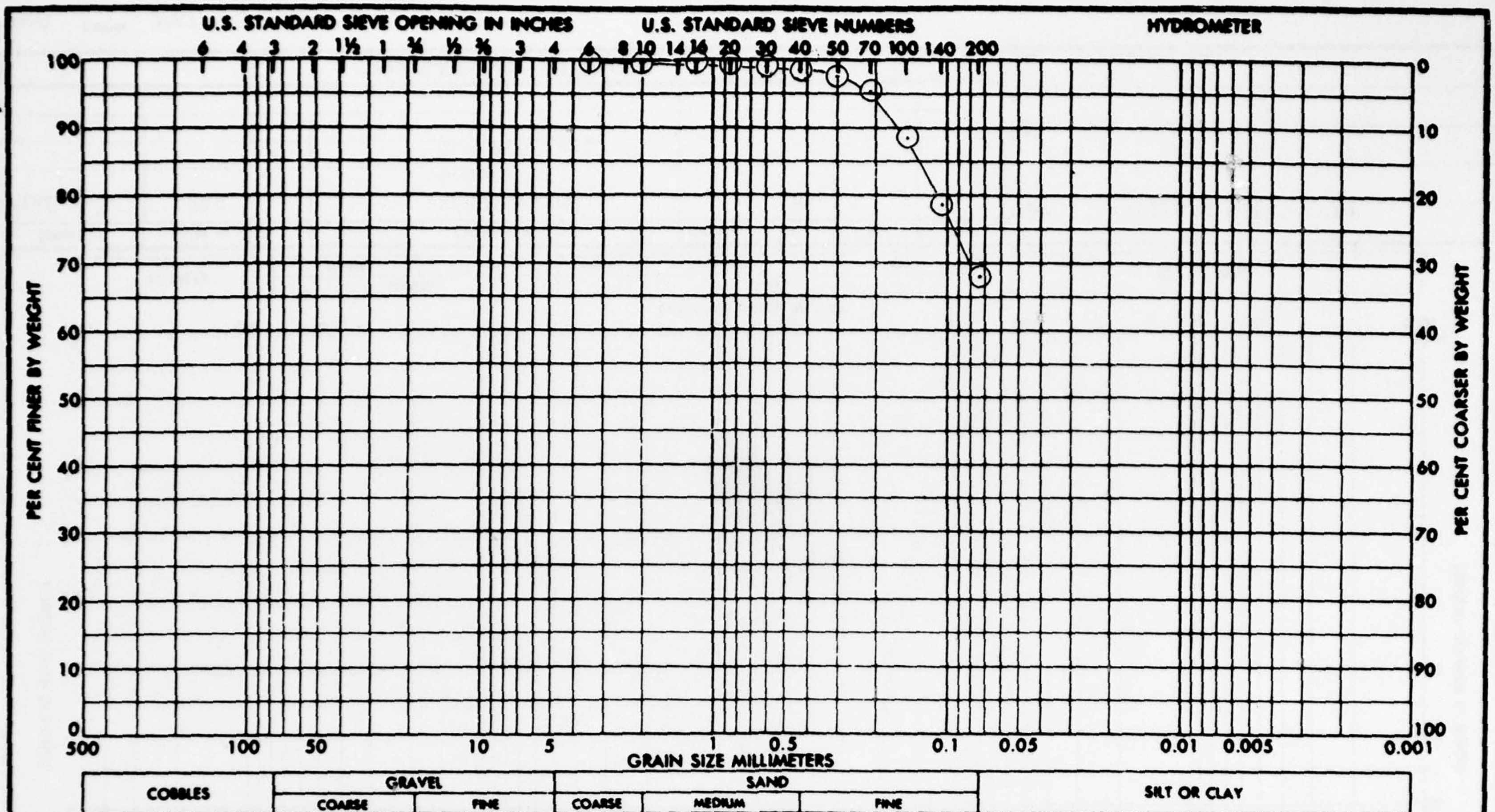

SAMPLE NO.	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
R-2 W-4	Bag	SANDY CLAY (CL) Light Brown Gs= 2.67(est)		36	15	21

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PLATE 6

Appendix A: Soil Chemistry Analysis

DEPARTMENT OF THE ARMY
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS
P. O. BOX 631
VICKSBURG, MISSISSIPPI 39180

IN REPLY REFER TO: WESCI

10 June 1977

MEMORANDUM FOR: SOILS AND PAVEMENTS LABORATORY

ATTN: MR. E. B. PERRY

SUBJECT: Results of Analysis of Soil from Louisiana Weirs

1. Six soil samples were received by the Chemistry and Plastics Branch. The samples were analyzed for cation exchange capacity (CEC), ammonium acetate extractable cations (Ca^{++}, Mg^{++}, Na^{+}, K^{+}), pH, and water extractable cations from saturated paste.

2. The test results are listed in Tables 1 and 2 (Incl 1 and 2).

Dennis L. Bean
DENNIS L. BEAN
Chemistry and Plastics Branch
Concrete Laboratory

2 Incl (dupe)
as

Table A1

Sample No.	Extractable Bases, meq/100 g Ca	Mg	K	Na	CEC meq/100 g	pH
R-1 W-1	10.2	7.3	0.2	1.8	19.9	7.4
R-1 W-2	9.9	4.2	0.2	0.4	13.5	6.0
R-2 W-1	9.2	5.2	0.2	0.4	12.3	6.5
R-2 W-2	1.7	0.8	<0.1	0.3	3.2	6.3
R-2 W-3	1.5	0.7	<0.1	0.3	2.8	6.8
R-2 W-4	8.2	4.0	0.2	0.3	15.2	5.2

Table A2

Sample No.	Water Extractable Cations, meq/l Ca	Mg	K	Na
R-1 W-1	11.1	10.5	<0.1	13.4
R-1 W-2	0.4	0.3	<0.1	0.6
R-2 W-1	0.4	0.5	<0.1	0.8
R-2 W-2	0.4	0.2	<0.1	0.4
R-2 W-3	0.1	0.1	<0.1	0.4
R-2 W-4	0.2	0.2	<0.1	0.3

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Miller, S Paul

Bank distress of low water weirs on Big Creek, La. / by S. Paul Miller. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1978.

27, [13] p., 6 leaves of plates : ill. ; 27 cm. (Miscellaneous paper - U. S. Army Engineer Waterways Experiment Station ; S-78-2)

Prepared for U. S. Army Engineer District, Vicksburg, Vicksburg, Miss.

References: p. 27.

1. Bank erosion. 2. Bank protection. 3. Big Creek, La. 4. Erosion. 5. Filter blankets. 6. Flow slides. 7. Slope protection. 8. Slope stability. 9. Weirs. I. United States. Army. Corps of Engineers. Vicksburg District. II. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Miscellaneous paper ; S-78-2.

TA7.W34m no.S-78-2